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LIFE CYCLE IMPACT ASSESSMENT (LCIA)

Ecodesign requirements for televisions—is energy consumption in the use phase the only relevant requirement?

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Abstract
Purpose This paper concerns the Ecodesign Directive (2009/125/EC) and the implementing measures (IM) in which ecodesign requirements are set up for energy-using and energy-related products. Previous studies have found that the requirements have a unilateral focus on energy consumption and the use phase. This is not in line with the scientific understanding of ecodesign, where attention should be put on all life cycle phases and all relevant environmental impact categories. This study focuses on the requirements for televisions (TV). A life cycle assessment (LCA) is carried out on two TVs to analyse if other environmental hotspots and life cycle phases should be included in the requirements in the IM of the Ecodesign Directive besides energy consumption in the use phase analysis.
Methods The consequential approach is used. The data for the LCA have been gathered from two manufacturers of TVs. In one case, the data were delivered in Excel spreadsheets; in the other case, the authors of this paper together with the manufacturer disassembled a TV and collected the data manually.
Results and discussion When applying the consequential approach, the production phase has the highest environmental impact, which is in contradiction with the focus area of the IM. The result of the sensitivity analysis is that the source of electricity is a potentially significant contributor of uncertainty. However, even in a coal-based scenario, the contribution from the production phase is approximately 30 %.
Conclusions Based on these results, it is concluded that for future requirement setting in IM, it is necessary to set up requirements that cover more life cycle phases of the product in order to address the most important impacts.

Keywords Ecodesign · Ecodesign directive · EU regulation · Impact assessment · Life cycle assessment · Product life cycle · Television

1 Introduction

The Ecodesign Directive (2009/125/EC) establishes a framework for setting ecodesign requirements for energy-using and energy-related products. The requirements are set up in implementing measures (IM), which are commission regulations. The IM are based on extensive preparatory studies and stakeholder involvement (European Commission 2011).

The study presented in this paper was initiated by the Danish Environmental Protection Agency due to concerns about the scope of the requirements in the IM. As of November 1, 2011, 12 IM have been adopted. All IM except the IM on electric motors set requirements to power consumption or energy efficiency. Other requirements are related to performance and quality issues. The only IM that stands out is the IM on washing machines, which also sets requirements for water consumption. According to Huulgaard and Remmen (2012) and Andersen and Remmen (2010, 2011), in general, only one environmental impact category and one life cycle phase is addressed in the IM, namely energy consumption in the use phase and energy efficiency. This unilateral focus is not in line with the scientific understanding of ecodesign. Ecodesign, in its scientific meaning, is about continuous improvement of many environmental parameters and in all life cycle phases

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(Brezet et al. 1997; Tischner et al. 2000; Zbicinski et al. 2006). Furthermore, a study by the European Environmental Bureau has indicated that the lifetime and thereby importance of energy in the use phase is likely to have been overestimated in the IM, especially in the case of televisions (TVs), monitors and computers (van Rossem and Dalhammar 2010).

This paper focuses on the IM for TVs, in which requirements are set up for power consumption in standby, on-mode and off-mode and information requirements. An LCA of one 32-in. and one 46-in. TV is presented. The aim of the study is to assess if the IM is addressing the most important impacts when setting requirements to energy consumption in the use phase. More specifically, the aim is to conduct an environmental impact assessment of the two TVs to assess the importance of energy consumption in the use phase and what other hot spots can be identified.

2 Methods

The approach taken in this paper is the consequential approach. Consequential modelling is characterized by excluding constrained suppliers and avoiding allocation by system expansion (Weidema et al. 2009). In this study, only affected suppliers are included in the electricity mix. System expansion is used for the waste treatment modelling, which implies the recycled materials (e.g. aluminium) substitute virgin materials. Furthermore, energy from incineration of waste substitutes electricity and heat. The substituted electricity mix is the same electricity mix used in the use phase. The substituted heat is 'Natural gas, burned in industrial furnace >100 kW/RER U' from Ecoinvent (2010).

The life cycle impact assessment method used in this study is the Stepwise2006 (Weidema 2007; Weidema et al. 2007). The impact assessment impact category indicators used are midpoint, and all available impact categories were selected for the assessment.

The functional unit is one TV including production phase, use phase and end of life. Two TVs with different screen sizes and data qualities, and from two different manufacturers are assessed in this study. The aim is to increase the empirical evidence of the findings by assessing two TVs. Hence, the results of this study cannot be used to perform any comparative assessments between the two TVs.

2.1 Data collection

The TVs assessed in this study were selected in collaboration with the TV manufacturers. The criteria for selection were that the TVs had to be representative of the manufacturer's collection of TVs in terms of sales figures and technology. The first TV is 46 in. in screen size and based on LED technology. The TV is installed on a wall bracket. The second TV is 32 in. in screen size and also based on LED technology. The TV is installed on a pedestal. Data for the 32-in. TV were provided directly in spreadsheets from the manufacturer, whereas the authors of this paper and the manufacturer of the TV disassembled a TV and gathered the data themselves for the 46-in. TV.

2.2 Data quality

The system boundaries of this study represent a cradle-to-grave perspective. Data on the 32-in. TV are from 2010, whereas data on the 46-in. TV are from 2011. The components of the 32-in. TV are produced in Asia, and the TV is assembled partly in Asia and Europe. For the 46-in. TV, the components are produced in Asia, Europe and the USA, and the assembly takes place in Europe. The wastes from both TVs are treated in Europe. It has been necessary to make a few assumptions in order to complete the assessments. Firstly, it is, based on the knowledge from the manufacturers, assumed that the two TVs are representative for the manufacturers' TV portfolio in terms of technology and screen size. Secondly, it is assumed that the components in the TVs are comparable to the components in the Ecoinvent database (Ecoinvent 2010). Data on the components of the LEDs are based on the study of Seong-Rin et al. (2011). Thirdly, the lifetime of the TV, hours daily turned on and the waste scenario are assumptions by the authors of this study, as described in the life cycle inventory (LCI).

2.3 Life cycle inventory—production

The production of an LCD TV includes the manufacture of all the components, the transport of the items, the assembling of the TV and the packaging. The inventory of the production stage of the 32- and 46-in. LED TVs is listed in Table 1 where it is structured in main categories. Auxiliary materials are not included in the assessment, but are assumed to be small. Material losses are included in the production processes, but not in the assembly processes. The electricity used for the assembling of the TV, packaging and production of the components is the same as applied in the use stage and is further described in the next paragraph. Only electricity used for aluminium production is the same as for the original dataset from Ecoinvent (2010).

2.4 Life cycle inventory—use stage

The inventory for the use stage of the TVs includes assumptions on the lifetime of the TV and watching time. These assumptions and information on power consumption are listed in Table 2. TV watching time is based on a report from the OECD (2009).

Table 1 Summary of material components in the life cycle inventory of the 32- and 46-in. TV. The entries marked in italics are processes and are not included in the weight of the TV. The unit of processes are kilograms unless otherwise indicated, and indicate the amount of material handled in the given process

Output	32-in. TV	46-in. TV
TV (kg)	10.81	52.5
Input	Weight (kg)	Weight (kg)
Housing		
Polycarbonate	0.53	0.42
Acrylonitrile butadiene styrene	0.08	0.99
Polyphenylene oxide		0.80
Foam		0.001
Glass fibre		0.15
Steel		14.38
Aluminium		3.47
Magnets		0.05
Glass	1.17	10.44
Cotton		0.01
Printed wiring board		0.001
Cables		0,004
Coating		*sqm 1.15*
Plastics processing	*2.11*	*2.36*
Steel processing		*14.38*
Aluminium processing		*3.47*
Nylon	0.002	
Polyphenylene ether	0.75	
Polystyrene	0.75	
Electronics box		
Printed wiring board	0.27	1.21
Steel	0.02	5.29
Cables		0.19
Connectors		0.09
Polycarbonate		0.01
Acrylonitrile butadiene styrene		0.01
Foam		0.02
Plastics processing		*0.01*
Connectors	0.04	
Integrated circuits	0.02	
Capacitors	0.03	
Wire-wound	0.18	
Capacitors (film)	0.02	
Resistors	0.0001	
Aluminium	0.05	
Soldering	*0.30*	
Aluminium processing	*0.05*	
Panel		
Steel		3.23
Tin		0.11
Foam		0.03
Printed wiring board		0.40
Light-emitting diodes	0.01	0.02
Cable		0.01
High-density polyethylene		1.01
Polycarbonate		1.30
Acrylonitrile butadiene styrene		1.30
Glass fibre		0.46
Rubber		0.01
Plexiglass		2.58
Cable		0.01
Glass		2.31
Plastics processing		*4.07*
Steel processing		*3.23*
LCD module	4.97	
Other components		
Polyphenylene oxide		0.47
Acrylonitrile butadiene styrene	0.03	0.54
Magnets	0.08	0.57
Iron		0.34
Polycarbonate	0.10	0.17
Aluminium		4.82
Rubber	0.02	0.06
Cotton		0.03
Foam		0.05
Cables	0.14	0.08
Paper		0.13
Flame retardant		0.02
Printed wiring board		0.02
Steel	1.22	0.03
Screws	0.07	0.26
High-density polyethylene		0.04
Plug		0.03
Polyphenylene ether	0.12	
Glass wool	0.01	
Printed wiring board	0.02	
Capacitor (film)	0.0002	
Integrated circuits	0.0003	
Transistor	0.0003	
Polystyrene	0.043	
Nylon	0.001	
Box	1.85	
Bags	0.07	
User guide	0.06	
Cardboard		5. 50
Expanded polystyrene	0.32	2.80
Wood		7.10
Plastics processing	*0.32*	*1.31*
Steel processing	*1.22*	*0.03*
Screws processing	*0.07*	*0.26*

Table 1 (continued)

Foaming	*0.32*	*2.80*
Soldering	*0.02*	
Transport	Ton km	Ton km
Road	*178*	*82*
Sea	*11*	*305*
Air	*0*	*121*
Energy for assembly		
Energy, in kWh	*52*	*274*
Heat, in MJ	*167*	*883*

The electricity mix used is modelled according to the consequential approach and only includes European suppliers which are forecasted to be affected by a change in demand in the future. The forecast is based on data for power generation in 2008 and predicted generation in 2020 in Europe, as published by IEA (2010a, b). These data are used to identify the suppliers that will increase their production (e.g. electricity based on wind and biomass) and suppliers that will decrease their production (e.g. electricity based on coal and oil) in the future. Only European suppliers that are increasing the production will be affected by a change in demand and are thereby included in the electricity mix used for the modelling. Fifty-eight percent of the electricity mix used for the modelling is wind based, because many of the European countries have decided to increase the share of wind-based electricity. On the contrary, the share of electricity based on coal, oil and nuclear sources is forecasted to decrease, and these suppliers will therefore not be affected by a change in demand in the coming years. The last 42 % of the electricity mix used for the modelling is based on natural gas, biomass, hydro, geothermal and solar energy. For further details, see Merciai et al. (2011) and Schmidt et al. (2011). The LCI of the respective electricity types are taken from Ecoinvent (2010).

2.5 Life cycle inventory—waste management

The waste management stage includes the end-of-life treatment of the LED TVs, as presented in Fig. 1. It is assumed that the collection rate is 100 %. It is assumed that, after the disassembly, printed wiring boards (PWBs), cables and LEDs follow a different path from the other materials of the TVs. The former go through a metal recovery process while the rest of the materials end up at recycling plants. Furthermore, it is assumed that there is no loss of materials in the disassembly process.

The transport distances were assumed to be 0 km from 'Consumer' to 'WEEE Centre', 200 km from 'WEEE Centre' to 'Disassembly plant', 200 km from 'Disassembly plant' to 'Recycling Plant' and 500 km from 'Disassembly plant' to 'Metal recovery plant'. The transport of the packaging of the TV from consumer to the recycling plant was assumed to be 200 km.

Waste treatment processes are considered as multifunctional activities according to the consequential approach; hence, a system expansion is applied. As usual, the primary activity is the waste management service with coproduction represented by the recycled raw materials or by the electricity and the heat in case of incineration. As the default methodology in Ecoinvent (2010) is attributional, it has been necessary to modify some specific processes in order to obtain the consequential-structured recycling processes and incineration. In some cases, additional information on recycling processes has been taken from the existing literature (Schmidt 2005; Legarth et al. 1995) while, in order to know the potential electricity and heat production, the data of the ELCD project have been used (JRC–IES 2010). Some components such as connectors and glass from the LCD module end in incinerators or landfill; for other components, the recycling rates vary from 77.9 % (wood) to 99 % (aluminium). For the plastics, where the efficiency is 92.5 % (Schmidt 2005), it is assumed that of the residual 7.5 %, half is landfilled and half is incinerated. It is assumed that the process for the metal recovery is blast furnaces and is applied only for PWB, cables and LEDs before recycling. The aim of this process is to separate the metallic part which may then be used as secondary raw materials. The metal recovery process does not have a coproduction of electricity and heat. The recycling efficiency for metals varies between 80 % (tin) and 99 % (copper).

Table 2 Inventory for the use stage of the TVs

Assumption	32 in.	46 in.
Lifetime in household	12 years	12 years
TV watching time per day	4 h	4 h
TV standby time per day	20 h	20 h
Days on holiday per household per year. TV is unplugged	28 days	28 days
Power consumption in on mode	52.7 W	147 W
Power consumption in standby mode	0.1 W	0.5 W
Power consumption when unplugged	0 W	0 W

3 Results

The result of the life cycle impact assessment is illustrated in Table 3 together with the result of the endpoint impact calculated in euro. The endpoint impact presents which environmental impact categories have the largest contribution to the environmental impact. It appears that for the 32-in. TV, global warming potential (GWP) contributes with 44 % of the total impact, and with respiratory inorganics potential (RIP), the contribution is 76 %. For the 46-in. TV, GWP alone contributes with 45 %, and together with RIP, the contribution is 79 % of the total impact. In the following, these two impact categories are analysed in detail.

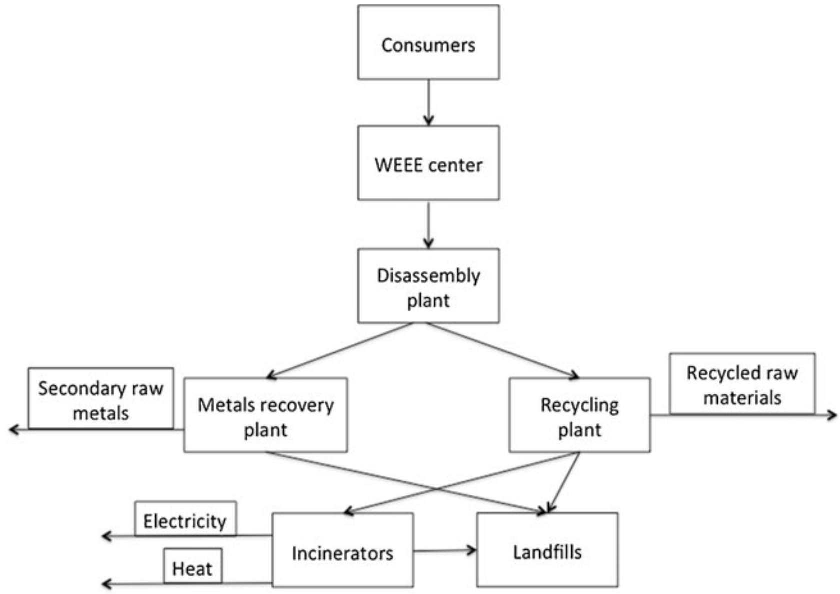

Fig. 1 Overview of the waste management system of a TV

3.1 Process contributions

The process contribution describes in detail which processes contribute to the potential impacts. The potential impacts are summarised in the four life cycle phases of the product. Table 4 illustrates the process contribution analysis.

From Table 4, it appears that the production stage has the highest contribution for both TVs. The contribution from the production to GWP corresponds to75 and 76 % of the total contribution for the 32- and 46-in. TVs, respectively. The contribution to RIP corresponds to 91 % of the total contribution for both TVs. The second largest contributing phase is the use phase, where the contribution to GWP corresponds to 38 and 31 %, respectively. For RIP, the contribution is 38 and 32 %, respectively.

The components with the highest contributions in the production phase for the 32-in. TV are firstly the assembled LCD module and secondly the electronics box. For the 46-

Table 3 Summary of the life cycle impact assessment from cradle to grave of the 32- and the 46-in. TV. LCIA method: Stepwise2006, midpoint (H) (Weidema 2007; Weidema et al. 2007)

Impact category	Midpoint result			Endpoint result				
	Unit	32 in.	46 in.	Unit	32 in.	%	46 in.	%
Total	–	–	–	EUR2003	73	100	246	100
Global warming	kg CO_2-eq	386	1,334	EUR2003	32	44	111	45
Respiratory inorganics	kgPM2.5-eq	0.35	1.2	EUR2003	23	32	83	34
Respiratory organics	pers*ppm*h	0.21	0.76	EUR2003	0.05	0.07	0.19	0.08
Human toxicity, carcinogens	kg C_2H_3Cl-eq	16	40	EUR2003	4	6	11	4
Human toxicity, non-carc.	kg C_2H_3Cl-eq	20	61	EUR2003	5	7	16	7
Ionizing radiation	Bq C-14-eq	3,067	9,826	EUR2003	0	0	0.0	0
Ozone layer depletion	kg CFC-11-eq	4.74E-05	1.58E-04	EUR2003	0	0.01	0.02	0.01
Ecotoxicity, aquatic	ton TEG-eq w	51,621	200,028	EUR2003	0.18	0.50	1	0.58
Ecotoxicity, terrestrial	ton TEG-eqs	4,358	13,690	EUR2003	5	7	15	6
Nature occupation	m^2 agr. land	4.5	17	EUR2003	0.56	0.76	2	0.83
Acidification	m^2 UES	39	121	EUR2003	0.30	0.41	0.94	0.38
Eutrophication, aquatic	kg NO_3-eq	1.8	2.7	EUR2003	0.37	0.25	0.28	0.11
Eutrophication, terrestrial	m^2 UES	39	152	EUR2003	0.49	0.67	2	0.77
Photochemical ozone, vegetat.	m^2*ppm*h	2,341	8,736	EUR2003	0.87	1	3	1
Non-renewable energy	MJ primary	5,548	19,533	EUR2003	0	0	0	0
Mineral extraction	MJ extra	21.5	93	EUR2003	0.09	0.12	0.37	0.15

in. TV, the highest contributing components are firstly the electronics box and secondly the assembled LCD module.

3.2 Sensitivity analysis

A sensitivity analysis is carried out on the source of electricity and the lifetime of the TV; see Table 5. It appears that when switching to coal-based electricity, the use phase becomes the life cycle phase with the highest contribution for both TVs and both impact categories with lifetimes of 10 and 12 years. With a lifetime of 6 years, the production phase continues to be the life cycle phase with the highest contribution. Reducing the lifetime of the TVs solely affects the contribution potential in the use phase.

4 Discussion

From Table 4, it is clear that the production phase has the highest impact potential both concerning GWP and RIP, and the use phase is only the second largest contributing phase. This is in contradiction with the IM, which sets requirements solely for the use phase.

The sensitivity analysis on coal-based electricity shows for both TVs that the contribution to GWP and RIP has increased in all life cycle phases, except the waste management phase. What is important to notice is that the use phase is now the life cycle phase with the highest contribution. The contribution from the use phase has increased from 38 to 68 % and from 31 to 63 %, respectively, for the 32- and 46-in. TVs. Even though the relative importance of the production phase has decreased similarly, the actual impact in the production phase has increased more than 50 % for the GWP. Hence, it is assessed that even in a coal-based scenario, the contribution from the production phase is too high to neglect in the requirements in the IM. Based on the analysis, it is found that the source of electricity production is a potential significant contributor of uncertainties.

The sensitivity analysis on the lifetime of the TV shows that the lifetime has an influence on the impact potential in the use phase. As use phase has shown not to be the most important life cycle phase, a reduction in the lifetime of the TV only strengthens the conclusions that the production phase is the most important life cycle phase. However, looking at the coal-based electricity scenario, the lifetime of the TV is significant in determining the life cycle phase with the highest environmental impact potential. With a lifetime of 12 years, as was estimated by the manufacturers, and a lifetime of 10 years as estimated in the IM, the use phase has the highest environmental impact, but with a lifetime of 6 years, the production phase has the highest environmental impact potential. There is a relatively large difference between the results using consequential electricity and using coal-based electricity. As an example, the global warming potential in a 12-year scenario for the 32-in TV is 288 kg CO_2-eq using consequential electricity, while it is 572 using coal-based electricity. The reason for this large difference is that while coal-based electricity has high CO_2 emissions, the consequential electricity is to a large extent based on wind power which is CO_2 neutral.

One condition in this study is important to discuss as it has influenced the results of the study. First, the two TVs analysed in this study are based on LED technology. TVs with this technology are, according to Samsung, up to 40 % more energy efficient than similar LCD TVs (Samsung Electronics Nordic AB n.d.). At the time when the preparatory studies were initiated in 2005, the LED technology was emerging, but was considered a niche market, and the cost of a TV with LED backlight was on average 70 % higher than traditional LCD TVs (Stobbe 2007). In the preparatory study, it was acknowledged that the LED technology had a significant potential for low power consumption, however, assessed not yet to be mature, which meant that the authors were not able to assess the actual environmental improvement, and hence, it did not influence the requirement setting in the IM (Stobbe 2007). However, the technological

Table 4 Process contribution analysis for the impact categories GWP and RIP. LCIA method: Stepwise2006, midpoint (H) (Weidema 2007; Weidema et al. 2007)

Life cycle stage	Global warming potential				Respiratory inorganics potential			
	32-in. TV		46-in. TV		32-in. TV		46-in. TV	
	kg CO_2-eq	% of total impact	kg CO_2-eq	% of total impact	kgPM2.5-eq	% of total impact	kgPM2.5-eq	% of total impact
Production	288	75	1,009	76	0.32	91	1.12	91
Transport	4	1	160	12	0.01	2	0.13	10
Use phase	147	38	414	31	0.14	41	0.40	32
Waste management	−53	−14	−249	−19	−0.12	−34	−0.42	−34
Total	386	100	1,334	100	0.35	100	1.22	100

Table 5 Sensitivity analysis concerning the use of coal-based electricity and the lifetime of the 32- and 46-in. TV. The figures for the 46-in. TV are listed in brackets. The table illustrates the process contributions for the impact category GWP and RIP for lifetimes 6, 10 and 12 years. LCIA method: Stepwise2006, midpoint (H), (Weidema 2007; Weidema et al. 2007)

Lifetime	Life cycle stage	Consequential electricity				Coal-based electricity			
		Global warming potential		Respiratory inorganics potential		Global warming potential		Respiratory inorganics potential	
		Kg CO_2-eq	% of total impact	Kg PM2.5-eq	% of total impact	Kg CO_2-eq	% of total impact	Kg PM2.5-eq	% of total impact
6 years	Production	288 (1,009)	92 (90)	0.32 (1.12)	115 (109)	572 (1,865)	54 (57)	0.55 (2.07)	68 (74)
	Transport	4 (160)	1 (14)	0.01 (0.13)	3 (12)	5 (170)	0.45 (5)	0.01 (0.13)	1 (5)
	Use phase	74 (207)	24 (18)	0.07 (0.20)	25 (19)	539 (1,515)	51 (46)	0.37 (1.04)	46 (37)
	Waste management	−53 (−249)	−17 (−22)	−0.12 (−0.42)	−43 (−41)	−59 (−280)	−6 (−9)	−0.12 (−0.44)	−15 (−16)
10 years	Production	288 (1,009)	80 (80)	0.32 (1.12)	98 (97)	572 (1,865)	40 (44)	0.55 (2.07)	52 (59)
	Transport	4 (160)	1 (13)	0.01 (0.13)	2 (11)	5 (170)	0.34 (4)	0.01 (0.13)	1 (4)
	Use phase	123 (345)	34 (27)	0.12 (0.33)	36 (29)	899 (2,525)	63 (59)	0.62 (1.74)	59 (50)
	Waste management	−53 (−249)	−15 (−20)	−0.12 (−0.42)	−37 (−36)	−59 (−280)	−4 (−7)	−0.12 (−0.44)	−12 (−13)
12 years	Production	288 (1,009)	75 (76)	0.32 (1.12)	91 (91)	572 (1,865)	36 (39)	0.55 (2.07)	47 (54)
	Transport	4 (160)	1 (12)	0.01 (0.13)	2 (10)	5 (170)	0.30 (4)	0.01 (0.13)	1 (3)
	Use phase	147 (414)	38 (31)	0.14 (0.40)	41 (32)	1,078 (3,030)	68 (63)	0.74 (2.09)	63 (54)
	Waste management	−53 (−249)	−14 (−19)	−0.12 (−0.42)	−34 (−34)	−59 (−280)	−4 (−6)	−0.12 (−0.44)	−10 (−11)

development has happened significantly faster than what was predicted in the preparatory study, and the actual TV sales confirm that LCD TVs, including the LED technology, are market leading (CSES 2012). Looking at the homepages of, for instance, Samsung and Sony reveals that more than 80 % of the available TVs are based on the LED technology (Samsung 2012; Sony 2012). This is furthermore underlined in Boks et al. (2011), where an overview of the technological development of best practice TVs within ecodesign is presented. This study is based on data from the European Imaging and Sound Association's Green Award, where TV manufacturers compete to have the most environmentally superior TV. The authors conclude that the state of the art within the ecodesign of TVs has progressed rapidly, illustrated by the fact that the first Green Award winner in 2005 was based on conventional CRT technology, and only 6 years later, in 2011, the winner TV was a slim-designed LED TV with a solar-powered remote control (Boks et al. 2011. It is the authors' assessment that even though the technology of the analysed TVs is considerably more energy efficient than the TVs used in the preparatory studies, this does not bias the result of this study. The televisions were chosen by the manufacturer on the criteria that they should be representative for their sales, and the market data support the market-leading position of the LED technology. Hence, this development and the results of this study merely underline the conclusion that as the TVs become more energy efficient in the use phase, it is imperative that requirements are also set up for the production phase. Furthermore, it underlines the conclusion from Andersen and Remmen (2010) who conclude that the process of developing the requirements in the IM is too slow and therefore is not able to take into account the fast technological development.

5 Conclusions

It is found that in the case of TVs, the IM are not addressing the most important impacts when exclusively setting requirements to energy consumption in the use phase. The impact of the electricity consumption in the use phase corresponds to 31–38 % of the total impact for the two TVs, and it is clear that the production phase is the largest contributor with 75–76 % of the total impact when applying the consequential approach. However, the sensitivity analysis shows that when applying 100 % coal-based electricity, the use phase is the most important life cycle phase. Even in this scenario, the production phase accounts for approximately 30 % of the total impact. The results of this LCA imply that for future requirement setting in IM, it is necessary to set up requirements that cover more life cycle phases of the product in order to address the most important impacts.

An analysis of the lifetime of TVs is recommended as these data would strengthen the LCA analysis and therefore also the requirement setting process. One aim of this project was to identify other hot spots besides energy consumption in the use phase of TVs. Only two of the 16 environmental impact categories in Stepwise2006 are presented in this report as these contributions represent nearly 80 % of the total environmental impact. GWP alone contributes with nearly 50 %. Hence, the other 14 environmental impact categories have very low contributions.

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